WHAT IS CLAIMED IS:

1. A method for diagnosis and prognosis of faults in a physical system comprising:

receiving sensor data representative of measurements made on the physical system, the measurements being representative of values of signals produced by the physical system;

receiving discrete data comprising system status variables and system command information;

producing model enhanced sensor signals by fitting the sensor data to a partial model of the physical system;

producing predicted system states based on the discrete data;

detecting discrepancies among the discrete data;

identifying suspected bad signals by detecting discrepancies among the sensor data based on a statistical model of the sensor data;

confirming detection of failures based on the discrepancies among the discrete data, on the suspected bad signals, and on the predicted system states; and

producing predicted faults based on a stochastic model of the sensor data to produce predicted values of the sensor data from the stochastic model, the predicted faults being based on the predicted values.

2. The method of claim 1 further including presenting information relating to the health of the system comprising detected discrepancies, a categorization of modeled and unmodeled events, and predicted faults, the information suitable for a human user or a machine process

3. The method of claim 1 further including identifying correlated signals from among the sensor data, comparing the correlated signals against expected correlated signals to detect occurrences of events.

4. The method of claim 3 further including identifying detected occurrences of events as unmodeled events based on the suspected bad signals and on the model enhanced signals.

5. The method of claim 3 wherein the correlated signals are based on a coherence coefficient, ζ_{ij}, defined by:

$$\zeta_{ij} = \frac{\left|Cov\left(S_i, S_j\right)\right|}{Max\left(Var\left(S_i\right), Var\left(S_j\right)\right)}, \text{ where}$$

S_i and S_j are the signals produced by the physical system,

$$Cov\left(S_i, S_j\right) = \frac{1}{t}\int\left(S_i - \overline{S}_i\right)\left(S_j - \overline{S}_j\right)dt, \text{ and}$$

$$Var\left(S_i\right) = \frac{1}{t}\int\left(S_i - \overline{S}_i\right)^2 dt.$$

6. The system health monitor of claim 1 further including producing statistical metrics based on the model enhanced signals and identifying unmodeled events by comparing the statistical metrics against predetermined metrics, the predetermined metrics indicative of known operating conditions of the physical system.

7. The system health monitor of claim 1 further including means for identifying statistical components in the sensor data so that the discrepancies in the sensor data are based only on the statistical components of the sensor data.

8. The system health monitor of claim 1 further including identifying a deterministic component in the sensor data, producing a residual component in the sensor data by removing the deterministic component, separating the residual component into a linear component, a non-linear component and a noise component, and fitting the linear component, the non-linear component and the noise component to a stochastic model, wherein the discrepancies among the sensor data are based on the stochastic model.

9. A system health monitor for diagnosis and prognosis of faults in a physical system being monitored comprising:

a model filter having at least a partial model representation of the physical system, the model filter operable to produce a plurality of model enhanced signals based on sensor data, the sensor data representative of measurements made on the physical system, the measurements being representative of values of signals produced by the physical system;

a symbolic data model operable to produce predicted system states based on discrete data comprising system status variables and system command information, the symbolic data model further operable to detect discrepancies among the discrete data;

a first anomaly detector operable to detect discrepancies in the sensor data based on a statistical model of the sensor data, the discrepancies in the sensor data constituting suspect bad signals;

a predictive comparator module operable to confirm a failure based on detected discrepancies among the discrete data, the suspected bad signals, and the predicted system states;

a prognostic assessment module operable to produce predicted faults using a stochastic model of the sensor data to produce future values of the sensor data from the stochastic model; and

a presentation module for presenting information relating to the health of the system comprising the detected discrepancies and the predicted faults, the information suitable for a human user or a machine process.

10. The system health monitor of claim 9 further including a second anomaly detector comprising: an incremental coherence estimator coupled to receive the model enhanced signals and operable to produce coherence estimates; a coherence library containing expected estimates coupled to receive the predicted system states and operable to output some of the expected estimates based on the predicted system states; and a coherence comparator module operable to detect occurrences of events based on a comparison of the predetermined estimates and the coherence estimates.

11. The system health monitor of claim 10 wherein the predictive comparator module is further operable to identify detected occurrences of events as unmodeled events based on the suspected bad signals and on the model enhanced signals.

12. The system health monitor of claim 10 wherein the second anomaly detector further comprises a convergence rate test module coupled to receive the coherence estimates and operable to detect when a convergence rate of the coherence estimates approaches a predetermined rate, the incremental coherence estimator being reset to an initial state when the convergence rate does not approach the predetermined rate.

13. The system health monitor of claim 9 further including a second anomaly detector comprising: means for producing statistical metrics based on the model enhanced signals; and means for identifying unmodeled events by comparing the statistical metrics against predetermined metrics, the predetermined metrics indicative of known operating conditions of the physical system.

14. The system health monitor of claim 9 further including means for identifying statistical components in the sensor data so that the discrepancies in the sensor data are based on the statistical components of the sensor data.

15. The system health monitor of claim 9 further including means for identifying a deterministic component in the sensor data; means for producing a residual component in the sensor data by removing the deterministic component; means for separating the residual component into a linear component, a non-linear component and a noise component, and means for fitting the linear component, the non-linear component and the noise component to a stochastic model, the discrepancies among the sensor data being identified based on the stochastic model.

16. A computer program product for diagnosis and prognosis of faults in a physical system comprising:

a computer readable medium having contained thereon computer instructions suitable for execution on a computer system,

computer instructions comprising:

first executable program code effective to operate the computer system to receive sensor data representative of measurements made on the physical system, the measurements being representative of values of signals produced by the physical system;

second executable program code effective to operate the computer system to receive discrete data comprising system status variables and system command information;

third executable program code effective to operate the computer system to produce model enhanced sensor signals by fitting the sensor data to a partial model of the physical system;

fourth executable program code effective to operate the computer system to produce predicted system states based on the discrete data;

fifth executable program code effective to operate the computer system to detect discrepancies among the discrete data;

sixth executable program code effective to operate the computer system to identify suspected bad signals by detecting discrepancies among the sensor data based on a statistical model of the sensor data;

seventh executable program code effective to operate the computer system to confirm detection of failures based on the discrepancies among the discrete data, on the suspected bad signals, and on the predicted system states; and

eighth executable program code effective to operate the computer system to produce predicted faults based on a stochastic model of the sensor data to produce predicted values of the sensor data from the stochastic model, the predicted faults being based on the predicted values.

17. The method of claim 16 further including ninth executable program code effective to operate the computer system to present information relating to the health of the system comprising detected discrepancies, a categorization of modeled and unmodeled events, and predicted faults, the information suitable for a human user or a machine process

18. The method of claim 16 further including ninth executable program code effective to operate the computer system to identify correlated signals from among the sensor data, comparing the correlated signals against expected correlated signals to detect occurrences of events.

19. The method of claim 18 further wherein the ninth executable program code is further effective to identify detected occurrences of events as unmodeled events based on the suspected bad signals and on the model enhanced signals.

20. The method of claim 18 wherein the correlated signals are based on a coherence coefficient, ζ_{ij}, defined by:

$$\zeta_{ij} = \frac{\left|Cov(S_i, S_j)\right|}{Max\left(Var(S_i), Var(S_j)\right)}, \text{ where}$$

S_i and S_j are the signals produced by the physical system,

$$Cov(S_i, S_j) = \frac{1}{t}\int (S_i - \overline{S}_i)(S_j - \overline{S}_j)\,dt, \text{ and}$$

$$Var(S_i) = \frac{1}{t} \int \left(\mathring{S}_i - \bar{S}_i\right)^2 dt .$$

21. The system health monitor of claim 16 further including ninth executable program code effective to operate the computer system to identify statistical components in the sensor data so that the discrepancies in the sensor data are based only on the statistical components of the sensor data.

22. The system health monitor of claim 16 further including ninth executable program code effective to operate the computer system to:

identify a deterministic component in the sensor data;

produce a residual component in the sensor data by removing the deterministic component;

separate the residual component into a linear component, a non-linear component and a noise component; and

fit the linear component, the non-linear component and the noise component to a stochastic model,

wherein the discrepancies among the sensor data are based on the stochastic model.

23. A system health monitor for diagnosis and prognosis of faults in a physical system being monitored comprising:

a model filter having at least a partial model representation of the physical system, the model filter operable to produce a plurality of model enhanced signals based on sensor data, the sensor data representative of measurements made on the physical system;

a symbolic data model operable to produce predicted system states based on discrete data comprising system status variables and system command information, the symbolic data model further operable to detect discrepancies among the discrete data;

a first anomaly detector operable to detect discrepancies in the sensor data based on a statistical model of the sensor data, the discrepancies in the sensor data being identified as suspect bad signals;

a second anomaly detector operable to identify unmodeled events by computing coherence statistics from the sensor data and comparing the coherence statistics against expected coherence quantities indicative of known operating conditions of the physical system;

a predictive comparator module operable to confirm a failure based on detected discrepancies among the discrete data, the suspected bad signals, and the predicted system states, the predictive comparator module further operable to distinguish the unmodeled events from modeled events based on the suspected bad signals and the model enhanced signals;

a prognostic assessment module operable to produce predicted faults using a stochastic model of the sensor data to produce future values of the sensor data from the stochastic model; and

a presentation module for presenting information relating to the health of the system comprising detected discrepancies, a categorization of modeled and unmodeled events, and predicted faults, the information suitable for a human user or a machine process.

24. The system of claim 23 wherein the statistical model is a model of the statistical components of the sensor data.

25. The system of claim 23 wherein the coherence statistics are based on a coherence coefficient, ζ_{ij}, defined by:

$$\zeta_{ij} = \frac{\left|Cov\left(S_i, S_j\right)\right|}{Max\left(Var\left(S_i\right), Var\left(S_j\right)\right)},\ \text{where}$$

S_i and S_j are time-varying signals represented by the sensor data,

$$Cov\left(S_i, S_j\right) = \frac{1}{t}\int\left(S_i - \overline{S}_i\right)\left(S_j - \overline{S}_j\right)dt,\ \text{and}$$

$$Var\left(S_i\right) = \frac{1}{t}\int\left(S_i - \overline{S}_i\right)^2 dt.$$

26. A method for diagnosis and prognosis of faults in a physical system being monitored comprising:

producing a plurality of model enhanced signals based on fitting sensor data to at least a partial model physical model of the physical system, the sensor data representative of measurements made on the physical system;

producing predicted system states based on discrete data comprising system status variables and system command information, the symbolic data model further operable to detect discrepancies among the discrete data;

detecting discrepancies in the sensor data based on a statistical model of only the statistical components of the sensor data, the discrepancies in the sensor data being identified as suspect bad signals;

identifying correlated signal among the sensor data;

identifying unmodeled events by comparing the correlated signals against expected correlated signals which are indicative of known operating conditions of the physical system;

confirming the detection of failures based on detected discrepancies among the discrete data, on the suspected bad signals, and the predicted system states;

producing predicted faults using a stochastic model of the sensor data to produce predicted values of the sensor data from the stochastic model; and

presenting information relating to the health of the system comprising detected discrepancies, a categorization of modeled and unmodeled events, and predicted faults, the information suitable for a human user or a machine process.

27. The method of claim 26 further including producing a statistical model of only the statistical components of the sensor data, including: identifying a deterministic component in the sensor data; producing a residual component in the sensor data by removing the deterministic component; separating the residual component into a linear component, a non-linear component and a noise component; and fitting the linear component, the non-linear component and the noise component to a stochastic model.